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What is claimed is:

1. A method for generating digital filters for tuning a hearing aid to enhance hearing ability comprising:
providing first digital data for a tolerance range for a target response curve representative of said enhanced hearing ability of sound level versus frequency;
providing second digital data representing an initial response curve of an initial hearing ability to be enhanced of sound level versus frequency;
comparing said first digital data to said second digital data and determining whether said initial response curve is within said tolerance range; and

if said initial response curve is not within said tolerance range, iteratively generating digital audio filters, applying said digital audio filters to said second digital data to generate third digital data for a compensated response curve, and automatically optimizing the frequency, amplitude and bandwidth of said digital audio filters until said compensated response curve is within said tolerance range or a predetermined limit on the number of digital audio filters has been reached, whichever occurs first. (page 34 - line 15 - page 35 - line 5)

2. A method according to Claim 1, wherein said step of iteratively generating digital audio filters is performed by iteratively generating second order filters. (see fig 5 and page 15 line 10 - 25)

24 3. The method of Claim 1 wherein said initial response curve is an
25 audiogram. (see Fig. 11)

26
27 4. A method for generating a set of second order filters to tune a hearing
28 aid to enhance hearing ability comprising:

29 providing first digital data for a tolerance range for a target response
30 curve representative of said enhanced hearing ability of sound level versus
31 frequency;

32 providing second digital data representative of an initial response curve
33 of an initial hearing ability to be enhanced of sound level versus frequency;

34 comparing said first digital data to said second digital data and
35 determining whether said initial response curve is within said tolerance range;
36 and

37 if said initial response curve is not within said tolerance range,
38 generating a set of filters to tune said hearing aid by performing the following
39 optimizing steps iteratively,

40 digitally processing said second digital data to determine an n^{th} (13 channel)
41 set of initial parameters for an n^{th} peak in said actual initial
42 curve where said initial response curve is not within said
43 tolerance range, including a frequency, and amplitude and a
44 bandwidth for said peak, where n is the number of an iteration of
45 said optimizing steps, digitally generating a compensating n^{th}
46 filter from said n^{th} set of initial parameters, applying said n^{th} filter

to said second digital data and modifying said n^{th} set of initial parameters to determine an n^{th} set of optimum parameters for said compensating n^{th} filter, to generate third digital data for an n^{th} interim compensated response curve of sound level versus frequency, processing said third digital data to determine whether said n^{th} interim compensated response curve is within said tolerance range, if said n^{th} interim compensated response curve is not within said tolerance range, performing another iteration of said optimizing steps until said interim compensated response curve is within said tolerance range or a predetermined limit on the number of filters has been reached, whichever occurs first.

5. A method of Claim 4, wherein said step of digitally generating a compensating nth filter is performed by digitally generating a second order filter.

6. The method of Claim 4, wherein said initial response curve is an audiogram.

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A method for generating filters for tuning a hearing aid to enhance hearing ability comprising:

providing first digital data for a tolerance range for a target response curve representative of said enhanced hearing ability of sound level versus frequency;

providing second digital data for an initial response curve of said hearing ability to be enhanced of sound level versus frequency;

comparing said first digital data to said second digital data and

determining whether said initial response curve is within said tolerance range; and

if said initial response curve is not within said tolerance range,

generating a set of compensating filters by performing the following single filter optimizing steps iteratively,

digitally processing said second digital data to determine an n^{th} set

of initial parameters for an n^{th} peak in said initial response curve

where said initial response curve is not within said tolerance range,

including a frequency, an amplitude and a bandwidth for said peak,

where n is the number of an iteration of said optimizing steps,

digitally generating a compensating n^{th} filter from said n^{th} set of initial parameters,

applying said n^{th} filter to said second digital data and modifying

said n^{th} set of initial parameters to determine an n^{th} set of

optimum parameters for said n^{th} filter, to generate third digital data for an n^{th} interim compensated response curve of sound level versus frequency;

if $n > 1$, performing the following joint filter optimizing steps iteratively and cyclically,

generating fourth digital data for interim computed response curves in which for each joint filter optimizing iteration one of said n filters is absent, and then performing said single filter optimization steps utilizing said fourth digital data to generate fifth digital data for an updated interim response curve,

digitally processing said fifth digital data to determine whether the most recent of said joint filter optimizing iterations has resulted in a change in said updated interim response curve greater than a predetermined amount of change, and if so continuing to perform said joint filter optimizing steps;

processing said fifth digital data to determine whether said n^{th} interim compensated response curve is within said tolerance range, and if not,

performing another iteration of the foregoing steps until said interim compensated response curve is within said tolerance range or a predetermined limit on the number of filters has been reached, whichever occurs first,

but if so, ceasing performance of further iterations.

8. A method according to Claim 7, wherein said step of digitally generating a compensating n^{th} filter is performed by digitally generating a second-order filter.

9. The method of Claim 8 wherein said initial response curve is an audiogram.

10. A method for generating filters for tuning a hearing aid to enhance hearing ability of an individual comprising:

fitting said hearing aid to said individual; (see abstract)

(Fig. 1) (26 R. 2.)
connecting said hearing aid to a source of audio digital signals; (10)

providing said individual with a device ^(16, 20) to generate indication signals at will;

generating and providing a first series of audio digital signals to said hearing aid, each signal in said first series of signals having a selected frequency and multiple power levels; (See page 38 ln 5-16)

receiving said indication signal during said generation of a signal of a
selected frequency indicative of said individual hearing said selected
frequency;

providing a digital audio processing unit in said hearing aid for processing received audio digital signals and providing processed audio

digital data, including applying digital audio filters for tuning said hearing aid characterized by coefficients in algorithms applied to said received audio digital signals to effect said digital audio filters; ⁽¹⁰⁾ page 38 in 27- page 39 in 10/ providing a digital computer ^(mouse) connected to receive said first series of audio digital signals and said indication signals to generate digital data representative of said individual's hearing ability using said hearing aid without filters determined from said first series of signals, said computer ^{on} programmed to determine said coefficients for digital filters for tuning said hearing aid and providing said coefficients to said digital audio processing unit in said hearing aid. (page 37 in 7-23)

11. A method according to Claim 10, wherein said digital computer is programmed to determine said coefficients by
- providing second digital data for a tolerance range for a target response ^(target curve) ?
- curve ability of representative of said individual's enhanced hearing ability of sound level versus frequency;
- providing first digital data representative of an initial response curve of ^(loss curve)
- said individual's hearing ability of sound level versus frequency;
- ^{file 10 (1018)} comparing said second digital data to said first digital data and
- determining whether said response curve is within said tolerance range;
- and
- if said response curve is not within said tolerance range,

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iteratively generating coefficients for digital audio filters, ^(threshold)
applying digital audio filters determined by said coefficients to said
first digital data to generate third digital data for a compensated
response curve, and
automatically optimizing said coefficients by optimizing the
frequency, amplitude and bandwidth of said digital audio filters until
said compensated response curve is within said tolerance range or
a predetermined limit on the number of digital audio filters has been
reached, whichever occurs first. (page 36 ln 9 - page 37 ln 6)

12. The method of Claim 11 wherein said computer receives said first
series of signals and indication signals generated by said device to generate
said first digital data. page 37 ln 25 - page 38 ln 16

13. The method of Claim 11 wherein said first digital data is an audiogram.
FIG. 11.

1 14. An apparatus for generating filters for tuning a hearing aid for use by
2 an individual, comprising:

3 a source of first audio digital data; ⁽¹⁰¹¹⁰⁾
4 a digital audio processing unit in said hearing aid for processing said first
5 audio digital data and providing processed audio digital data to said
6 individual, including applying digital audio filters for tuning said hearing

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aid characterized by coefficients in algorithms applied to said first audio

digital data to effect said digital audio filters; (col 13 ln 5-65)

a device for generating indication signals⁽¹⁶⁾ indicative of said individual

receiving said first audio digital data; and (page 37 ln 5 - page 38 ln 5)

a digital computer⁽¹⁷⁾ connected to receive said first audio digital data and

said indication signals, said digital computer programmed to determine

said coefficients for digital filters for tuning said hearing aid and provide

said coefficients to said digital audio processing unit. (page 38 ln 5-16)

15. An apparatus according to Claim 14, wherein said digital computer is programmed to generate second digital data representative of said individual hearing ability when using said hearing aid without filters determined from said first audio digital data and said indication signals and to determine said coefficients by

providing third digital data^(target curve) for a tolerance range for a target response curve of enhanced hearing of sound level versus frequency;

providing said second digital data^(loss curve), wherein said second digital data represents an initial response curve of hearing ability of sound level versus frequency;

comparing said third digital data to said second digital data and determining whether said initial response curve is within said tolerance range; and (See Fig 10 1018)

if said initial response curve is not within said tolerance range,

iteratively generating coefficients for digital audio filters,
applying digital audio filters determined by said coefficients to said
second digital data to generate fourth digital data for a
compensated response curve, and
automatically optimizing said coefficients by optimizing the
frequency, amplitude and bandwidth of said digital audio filters until
said compensated response curve is within said tolerance range or
a predetermined limit on the number of digital audio filters has been
reached, whichever occurs first. (page 36 l 9 - page 37 l 6)

16. A method for generating digital filters for tuning a hearing aid to
enhance hearing ability, comprising:
providing first digital data for a tolerance range for a target response
curve representative of said enhanced hearing ability of sound level
versus frequency;
providing second digital data representing an initial response curve of an
initial hearing ability to be enhanced of sound level versus frequency;
comparing said first digital data to said second digital data and
determining whether said initial response curve is within said tolerance
range; and
if said initial response curve is not within said tolerance range,

TI-29986-0002-9650

12 iteratively generating digital audio filters to compensate said initial
13 response curve,
14 applying said digital audio filters to digital signals representative of
15 received sound to generate third digital data, converting said third
16 digital data to an analog signal and providing said analog signal to
17 a speaker in said hearing aid,
18 generating fourth digital data representative of an enhanced
19 response curve of hearing ability of sound level versus frequency;
20 comparing said first digital data to said fourth digital data and
21 determining whether said enhanced response curve is within said
22 tolerance range; and
23 automatically optimizing the frequency, amplitude and bandwidth of
24 said digital audio filters until said enhanced response curve is within
25 said tolerance range or a predetermined limit on the number of
26 digital audio filters has been reached, whichever occurs first.

1 17. A method according to Claim 16, wherein said step of iteratively
2 generating digital audio filters is performed by iteratively generating second-
3 order filters.

5 18. The method of Claim 16 wherein said initial response curve is an
6 audiogram.

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8 19. The method of Claim 18 wherein said enhanced response curve is an
9 audiogram.

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11 20. A method for generating total log-integral metric digital data for
12 characterizing the perceived performance of a hearing aid, comprising the
13 steps of:

14 providing first digital data for N samples for a desired response curve of
15 acceptable hearing ability of sound level versus frequency;

16 providing second digital data representing N samples for an initial
17 response curve of sound level versus frequency; and

18 generating total log-integral metric data according to the formula:

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$$M = \sum_{i=1}^{N-1} \log_{10} \left(\frac{f_{i+1}}{f_i} \right) \left[\frac{|S(f_i)_{dB} - D(f_i)_{dB}| + |S(f_{i+1})_{dB} - D(f_{i+1})_{dB}|}{2} \right]$$

where:

M is the total log-integral metric,

f is the frequency,

D is the first digital data,

S is the second digital data, and

N is the number of samples of first digital data and of second
digital data.